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9

Cost Estimating

Introduction

The cost to produce products involves many different categories such as materials and equipment, method of purchasing materials and equipment, additives used, and fabricating costs (Fig. 9-1). All these factors have a direct effect on a designed product even though the designer is not involved in most of them. However it could very easily influence the expected initial cost that the designer had to include in the design evaluation. As experience tells one, cost of material can be very variable.

Interesting is the fact that the actual time and cost to design products may take less than 5% of the total time and cost to fabricate products. Even though this is a relatively small percentage of the overall operation, it has a direct and important influence performancewise and costwise on the success or failure of fabricating products.

A major cost advantage for fabricating products is their usual low processing cost. The most expensive part of the product is the cost of plastic materials. Since the material value in a plastic product is roughly up to one-half (possibly up to 80%) of its overall cost, it becomes important to select a candidate material with extraordinary care particularly on long production runs. Cost to fabricate using most processes and particularly in long runs usually represents about 5% of total cost. Thus with the product to be fabricated in-house, it can be economically beneficial to replace existing equipment to meet a lower product cost, as many do. The expensive equipment cost would be justifiable.

In purchasing equipment consider what John Ruskin (1819–1900) stated that it is unwise to pay too much, but it is unwise to pay too little unless you know that the machine is capable of meeting the requirements you set.

It is a popular misconception that plastics are cheap materials. There are low cost types but there are also the more expensive types. Important that one recognizes that it is possible to process a more expensive plastic because it provides for a lower processing cost (1–10, 20, 37, 64).

To put plastics in its proper cost perspective, it is usually best to compare materials based on volume rather than the weight used. On a weight basis most plastics can be more expensive than steel, and only slightly less than aluminum (Fig. 9-2). Examples of other cost factors to consider are reviewed in Figs. 9-3 to 9-5.

Cost-effective production of high-quality plastic products is the prime target of the plastic processor. As an example, the continually growing pressure from the competition demands the choice of IMMs with the smallest possible injection and clamping units in order

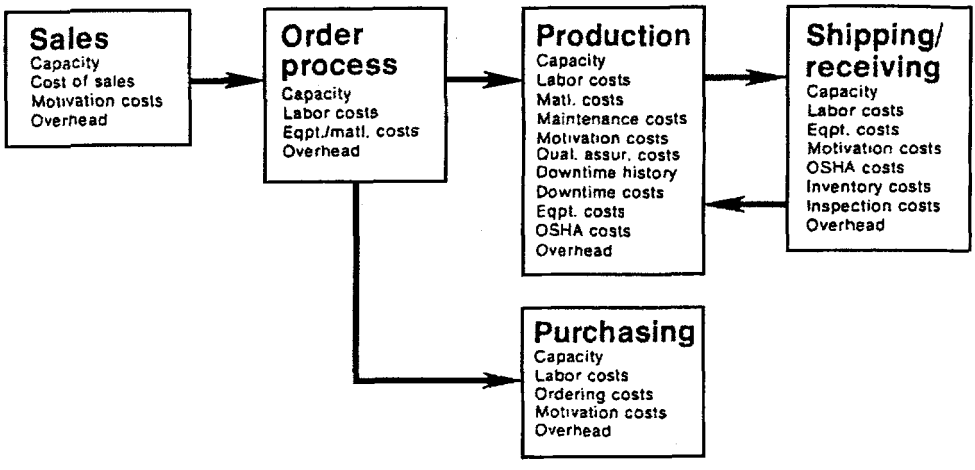

Fig. 9-1 Examples of cost factors.

to minimize the product costs by reducing investment and (important) operation costs. At the same time, however, these savings must not be made at the expense of product quality. This example is applicable to other processes such as extrusion, blow molding, and thermoforming.

To obtain the equipment needed a simple basic approach can be used. Design the product determining the plastic material to be used. Next design and plan building the mold or die to meet the product requirements. Now you are ready to determine the fabricating equipment required. It will be based on two factors: (1) the mold or die size and movements it requires and (2) the plastic material processing requirements. Thus the equipment purchased will only meet the requirements it has to meet. Probably one of the most difficult aspects of purchasing

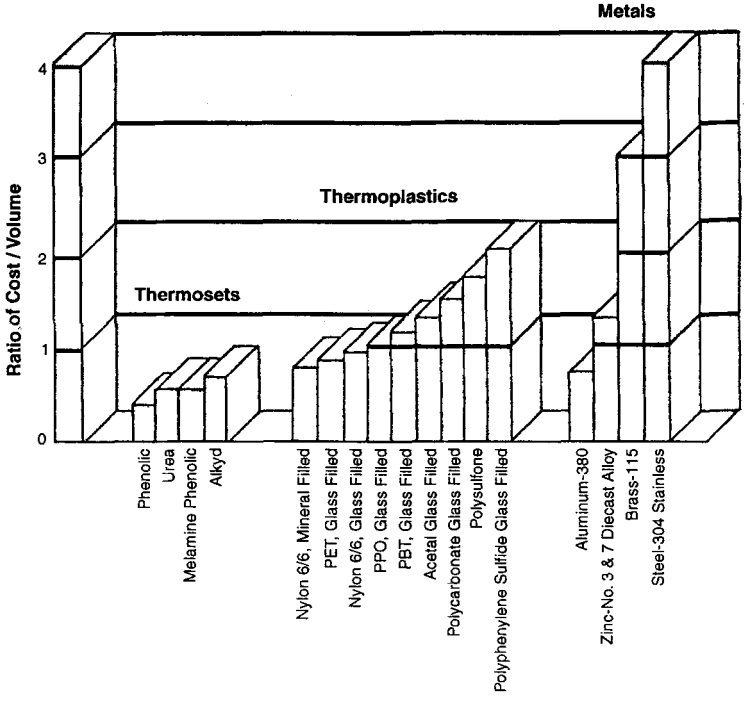

Fig. 9-2 A general plastic cost comparison, based on volume, for a general classification of materials.

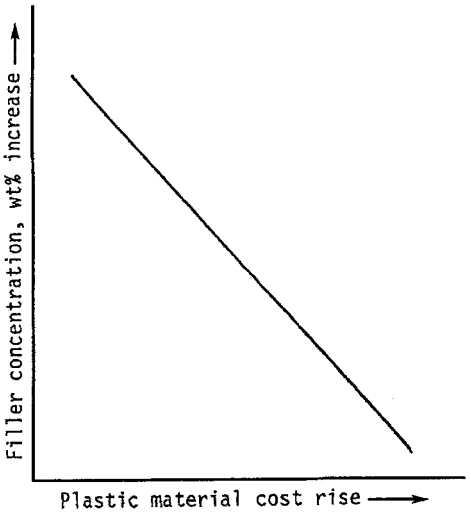

Fig. 9-3 Example why fillers become more attractive as plastic prices go up.

equipment is ensuring that the quotes solicit from different machine manufacturers are comparable. With the preparation of a complete detailed specification, particularly when unusual requirements exist on what is required, the quotes will be more compatible.

When designing a plastic product, it is frequently desirable to compute an approximate cost in order to determine whether the considered design is within desired economical limits. Based on the preliminary design configuration and type of material to be used, a determination has to be made regarding the fabricating process to be used. Considerations used include the number of products to be made and probably a time schedule that has to be met. There may be options where different plastics are being considered and also different processes. Ideally if history exists on similar products, available data can be used as a guide to develop a cost analysis.

If the designer is not familiar with fabricating plastic products, the usual practice is to contact a reliable fabricator(s), obtain a rough estimate(s), and proceed on the basis of this information to either redesign or finish the design on hand. This is time consuming, and on many occasions even this step is neglected because of time not available. To be efficient in designing products a qualified person should be included who is familiar with the different processing techniques.

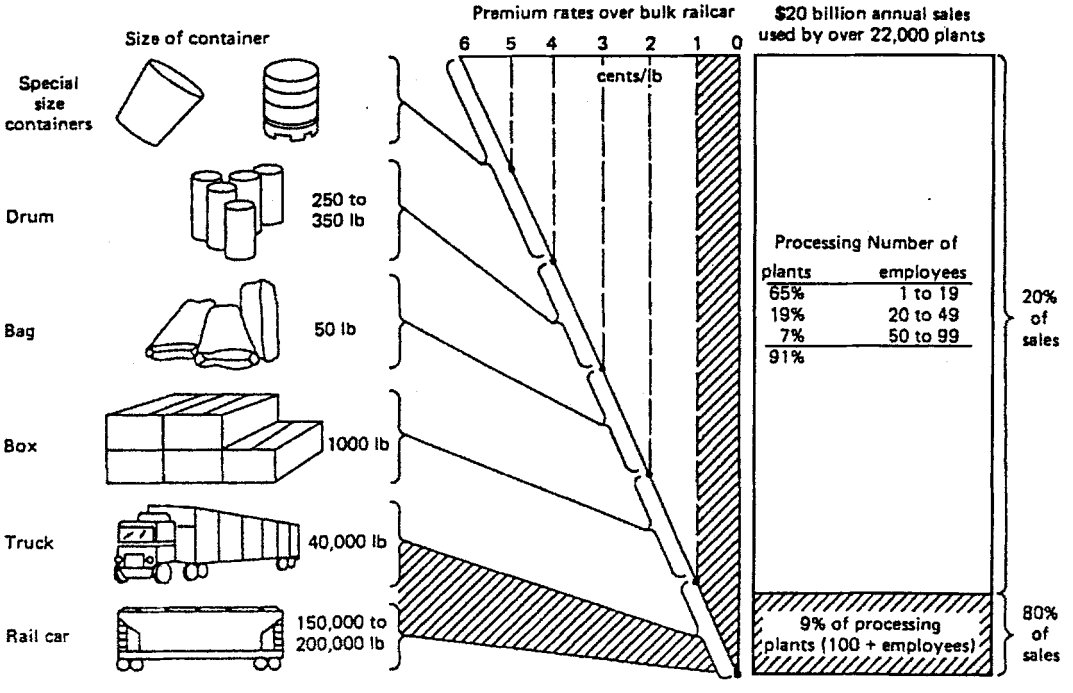

Fig. 9-4 Estimated plastic dollar purchases by plant size and size of containers.

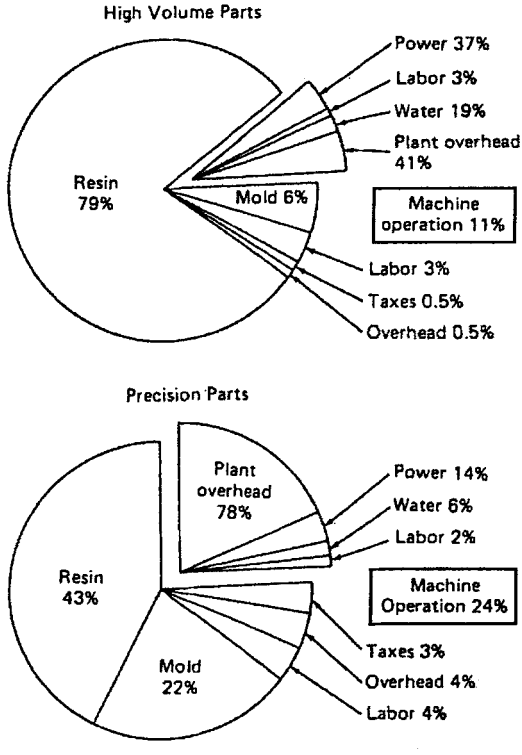

Fig. 9-5 Cost example of injection molding high-volume and precision products.

What may be an inefficient approach to costing a process is for the design group to have a specific manufacturing operation in-house. The companies target is to use their equipment that includes certain sizes. Perhaps the only jobs they take can only fit in their equipment which is OK. However, if they imprevize there is the possibility that a competitor will provide lower cost products using just the appropriate equipment. In the past many decades for companies with the big production products, they design the products, the molds or dies are designed to produce the products, and literally they design the manufacturing equipment around the mold or die. In turn they order new equipment to meet their specifications usually replacing in-house existing equipment. Many of these companies at that time, as at present have better qualified people in designing equipment than certain equipment producers.

The following information concerns injection molding a product. It is a practical and very simplified guide of costing. It covers the main and significant factors that include 85–90% of product direct value and should suffice for the requirements of a product designer when various designs are comparatively evaluated. The two basic ingredients that determine the value of a plastic product are the cost of the plastic material and the cost of fabrication.

Calculating the volume ($in.^3$ or cm^3) of the product and multiplying it by cost per the volume unit derives the cost of the plastic material content. Once the volumes of the product are established, one will utilize these data as the basis for obtaining the remainder of the information.

Cost of processing can start by taking the thickest portion of the product that will determine the processing time required. With a contemplated yearly activity and an ordering frequency of say every 45 days, one can tentatively decide on the number of cavities needed when molds are involved. The number of cavities should be such that it would take the 45-day requirement to produce in two hundred hours. Thus the number of

cavities times the volume per cavity leads to the machine size.

There are many cases in which the volume of material for all the cavities is small and the projected areas of the cavities are large. In this example, the choice of machine size is governed by the tonnage of the clamp required to keep the mold from opening during the fabricating process (3).

As an example for most plastics the usual is 2–5 tons/in.^{2}. For certain plastics pressure could go up to 15 tons/in.^{2}. Both the material volume and tonnage have to be satisfied while deciding on a machine size and, therefore, machine cost per hour. The larger press of the two requirements should prevail. When machine size in terms of volume and tonnage is decided upon, the molding cost can now be established. Molding cost per hour divided by pieces per hour gives molding cost per piece.

During the checking of volume against the press tonnage, only 70% of the machine volumetric capacity should be considered as the useful volume. The reason for this downgrading is that the heating capacity is based on polystyrene and most other materials require more energy for plasticating than does polystyrene. If the calculated volume for a product is more than 70% of rating, the selection calls for a higher tonnage press.

When using other processes, such as extrusion, blow molding, rotational molding, etc., cost of fabrication is usually related to the size of the product and output rate. Those familiar with any of these processes can easily and quickly provide cost information. What exists and required is experience in the different processes. For the designer not familiar with processes relying on the best-cost analysis can be a problem particularly if time does not exist to contact different fabricators. Recognize that those providing you a cost includes in their estimate factors such as their interest in obtaining the job, the odds of obtaining the job, how busy is their operation, are they helping a competitor, etc. Final quoted costs may differ from approximate cost estimates because quotations will include such features as close tolerances and special performance requirements not previously listed.

We now have the means of obtaining the material cost as well as the manufacturing cost per piece. Consider the sum of these two costs multiplied by 1.2 gives the complete cost. The 20% addition is to cover other elements of expense (probably accidentally not included) as well as a safety factor. The description of the method of cost computing may give the impression of a lengthy procedure; however, the actual performance of the estimating will prove brief and will be worthwhile in doing. The described cost estimates are intended for comparative design evaluation.

Effective Control

Properly training employees will help (and even eliminate) variable costs. In addition to other forms of training, such as shop floor training, seminars, video, and reading, implementing an interactive in-house training program becomes an important cost-effective form of educating the workforce. Effective training is essential to the survival and growth in today's world of plastics. Interactive training has proved to be the best way to provide employees with skills and knowledge that ultimately creates a more confident and productive workforce. An example of this service is available through different schools and organizations such as the University of Massachusetts-Lowell or Penn State at Behrend, PA.

Technical Cost Modeling

A wide range of processes, materials, and economic consequences characterizes the adoption of any technology for producing manufactured products. Although considerable talent can be brought to bear on the processing and designing aspects, economic questions can remain. Cost problems are particularly acute when the technology that will be employed is not fully understood, as much of cost analysis is based on historical data, past experience, and individual accounting practices.

Historically, technologies have been introduced on the shop floor incrementally, with their economic consequences measured directly. Although incorporating technical changes in the plant to test their viability may have been appropriate in the past, it is now economically infeasible to explore today's wide range of alternatives in this fashion. Technical cost modeling (TCM) has thus been developed as a method for analyzing the economics of alternative manufacturing processes without the prohibitive economic burden of trial-and-error innovation and process optimization (3, 20).

TCM is an extension of conventional process modeling that particularly emphasizes capturing the cost implications of process variables and economic parameters. By coordinating cost estimates with processing knowledge, critical assumptions (processing rates, energy used, materials consumed, scrap, etc.) can be made to interact in a consistent, logical, and accurate framework of economic analysis, producing cost estimates under a wide range of conditions.

For example, TCM can be used to determine the plastic process that is best for production without extensive expenditures of capital and time. Not only can TCM be used to establish direct comparisons between processes, but it can also determine the ultimate performance of a particular process, as well as identifying the limiting process steps and parameters.

TCM uses an approach to cost estimating in which each of the elements that contribute to the total cost is estimated individually. These individual estimates are derived from basic principles and the manufacturing process. This reduces the complex problem of cost analysis to a series of simpler estimating problems and brings processing expertise rather than intuition to bear on solving these problems.

In dividing cost into its contributing elements the first distinction to be made is that some cost elements depend upon the number of products produced annually, whereas others do not. For example, the cost contribution of the plastic is the same regardless of the number of items produced, unless the material price is discounted because of high volume. On the other hand, the per-piece cost of tooling will vary with changes in production volume that is influenced by maintenance, wear, etc. These two types of cost elements, which are called the variable and fixed costs, respectively, create a natural division of the elements of manufacturing product cost.

Basically the variable cost elements are those elements of piece cost whose values are dependent on the number of pieces produced. For most plastics fabrication processes the principal variable cost elements are the material, direct labor, and energy costs.

Fixed costs are those elements of piece cost that are a function of the annual production volume. Fixed costs are called fixed because they typically represent one-time capital investments (buildings, silos, processing machines, etc.) or annual expenses unaffected by the number of products produced (building rent, engineering support, administrative personnel, etc.). Typically, these costs are distributed over the total number of products produced in a given period. For plastics processes the principal elements are main machine cost, auxiliary equipment cost, tooling cost, building cost, overhead labor cost, maintenance cost, and the cost of capital.

To demonstrate the use of such a comparative cost analysis, the production of a panel was analyzed according to different processes (Fig. 9-6). In these case studies the following conditions existed: (1) the panels measured 61 × 91 cm (24 × 36 in.) with the wall thickness dictated by the process and part requirements so that the weights of the panels differed; (2) production was at a level of 40,000/yr.; (3) the plastics for all panels were of the same type, except that different grades had to be used, based on the process requirements, so that costs changed; (4) each panel received one coat of paint, except that the structural foam also had a primer coating; and (5) costs were allocated as needed to those processes that required trimming and other secondary operations.

TCM can keep cost data current, based on cost changes from day to day, region to region, and so on. Of course, the means of keeping these data updated require that those

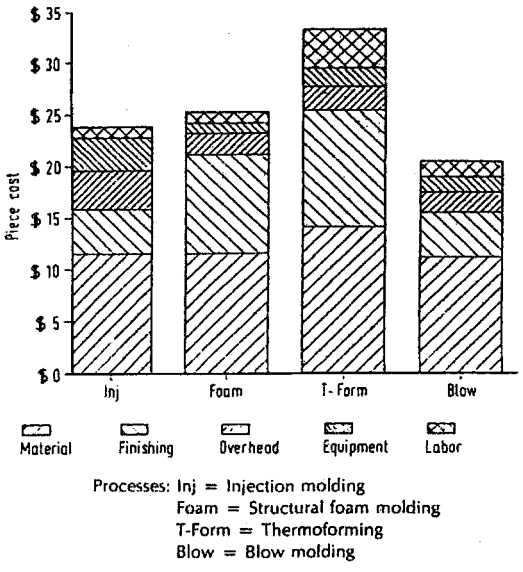

Fig. 9-6 Cost comparison of panel production using TCM program that shows blow molding with the lowest product cost.

costs be obtained on a regular basis and incorporated into the TCM.

Mold/Die Cost

Cost breakdown of a high production mold or die is approximately as follows: Material cost used to about 12 to 20%, design about 5 to 10%, mold building hours about 40 to 60%, and profit at about 5 to 10%. In general they are very expensive with the major cost principally in machine building labor. The proper choice of materials of construction for their different parts is paramount to quality, performance, and longevity of a mold/die. Add good machinability of component metal parts, material which will accept the desired finish (polished, textured, etc.), ability to transfer heat rapidly and evenly, capability of sustained production without constant maintenance, etc.

Using low cost material to meet high performance requirements will compromise their integrity. As an example, the cost of a mold cavity and core materials, for more than 90% of the molds, is less than 5% of the total mold cost. Thus it does not make sense to compromise mold integrity to save a few dollars; use the best material for the application. There are molds that run a few hundreds to many millions. Design and construction that relates to cost of a mold or die depends on the lifetime required.

An unwritten rule says that a mold or die should cost almost half the cost of the basic machine (injection, extrusion, blow molding, etc.). If it does not then something is wrong such as you probably have an oversized machine for the job for the lower cost mold or die.

Cost Analysis Method

Cost-Benefit Analysis

CBA is the economic analysis, such as with design developments and research programs, in which both the inputs to produce the intervention (or costs) and its consequences or benefits are expressed in monetary terms of net savings or a benefit-cost ratio. A positive net saving or a benefit-cost ration greater than one indicates the intervention saves money.

Direct and Indirect Cost

They are the operating quality costs of prevention and appraisal that are considered to be controllable quality costs. Add that in year 2000 the IRS decided to let companies deduct ISO 9000 costs as a business expense. Also there are the internal and external failure costs. As the controllable cost of prevention and appraisal increases, the uncontrollable cost of internal and external failure decreases. At some point the cost of prevention and appraising defective product exceeds the cost of correcting for the product failure. This point is the optimum operating quality cost.

In addition to the direct operating quality costs, the indirect quality costs and their effect on the total cost curve must be considered. Indirect quality costs can be divided into three categories: customer-incurred quality costs, customer-dissatisfaction quality costs, and loss-of-reputation costs. These

intangible, indirect quality costs are difficult to measure; however, they do effect the total quality cost curve. This influence is apparent when the indirect quality costs are added to the direct cost curve. When the optimum point increases, it indicates the need for a lower product defect level. A lower product defect level can be obtained by increasing the prevention and appraisal costs, which subsequently lowers the external failure costs. A lower external failure has a desirable influence on the direct costs. The measurement of the actual indirect costs may be impossible. However, a knowledge that these costs exist and their relationship to the direct costs can aid in their control (3).

Cost Effectiveness

Minimizing costs is generally an overriding goal in any application, whether designing a product, selecting a material, or a process is being selected for a new product or opportunities are being evaluated for replacing existing materials. The major elements of cost, are equipment and material with those that could be called inefficiencies such as scrap, repairs, waste, and machine downtime. Even though the scrap is recycled, it cost to granulate, handle, and possible slow down the line. Each of these elements must be evaluated before determining the most cost-effective approach.

Cost-Effectiveness Analysis

CEA is the economic analysis in which the consequences or effects of intervention are expressed in improvements such as fabricating successful products, years of service, etc.

Cost Estimating

Estimating is a critical aspect that ranges from designing to fabrication. Particularly in fabrication it is often practiced with very little logic. It is shrouded in mystery and rarely discussed by processors. Indeed, it is considered among the dullest of topics. It is extraordinary if one estimate in ten produces a successful bid. In other words, a 90% failure rate is terrific. No wonder estimating seems like some bizarre sacrificial rite. That does not include those estimates you just go through the motions of preparing because another company is going through the motions of getting three bids, and you have no chance at all of landing the job. Or that company's supplier is overloaded or had an accident, so the customer needs "temporary" help and you know it; in which case provide the high end of the bid (to be safe).

But what more directly represents the heart of a fabricator's business than estimating? You are pulling together every facet of your operation, distilling it, putting numbers on it, and putting your company on the "line." You are stating that this is what we can do, and this is what we must charge to make a normal profit. There are probably as many estimating techniques as there are estimators.

Cost Estimating Factor

Much contemporary estimating follows very vague procedures. The number of factors assembled to reach the appropriate figures is sometimes alarmingly small. Some may not consider scrap, coloring, setup time with trial and error, and so on to mention some of the more obvious omissions. Some estimates, that can work, are simple creations such as determining the part volume or weight, cost of plastic, and processing time; scribbling down some numbers; and adding a fudge factor (possible a little prayer). Some companies do not even have their own standard forms whereby they could develop some useful history. Of course what influences how one estimates generally relates to the fact that plastic processing is a highly competitive industry, so logically spend the time to prepare quotes where a payoff has a possibility to occur.

Cost Reduction

When it is possible, observing the following usual practices for extrusion will help to reduce costs (relate them to your process):

(1) strive for the simplest shape and form; (2) combine parts into single extrusions or use more than one die to extrude products/use multiple die heads and openings; (3) make gradual changes in thickness to reduce frozen stress. (4) where bends occur, use maximum permissible radii. (5) purchase plastic material as economical as possible. (6) keep customers tolerance as liberal as possible, but once in production aim for tighter tolerances to save material costs and also probably reduce production costs.

Cost Target

The production flexibility of the plastics fabrication processes is often the single most important economic factor in producing a product. The products size, shape, complexity, strength, orientation, etc. can be primary determinants but not impossible to produce. Thus, processing takes on the task of doing the "impossible" at the lowest cost (Fig. 9-7). Economics can be improved by targeting various factors. (1) reduction in the use of material by minimizing tolerances. (2) improvement in product quality in terms of strength and/or other mechanical-physical characteristics, (3) reduction in setting-up times of start-up aids and automation systems, and (4) savings in electricity consumption by the optimization of the plasticizing and the use of efficient heating and cooling systems.

Variable Cost

Processing cost variations may be due to one or more of the following factors: (1) improper or unattainable performance requirements; (2) improper plastic selection; (3) improper in-line and off-line hardware and control selections; (4) improper selection of the complete line; (5) improper collection and/or handling at the end of the line; and (6) improper setup for testing, quality control, and troubleshooting.

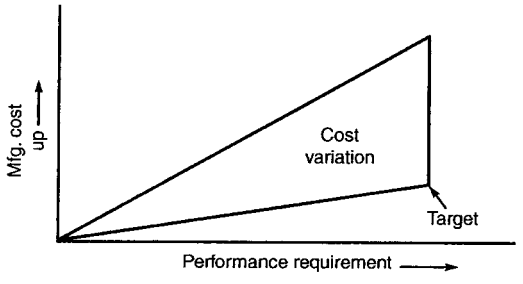

Fig. 9-7 Target to meet performance requirements at the lowest cost.

Energy Cost

Cost savings via energy conservation can be considered from the viewpoints of machine operation, the plastic material, and the finished product. Fabricating machines are usually energy intensive. Thus it becomes obvious to reduce the energy requirements where it is possible starting with the purchase of any equipment in the line that provides reducing energy consumption.

Product Cost

In a production line that has a relatively long run, the cost for equipment in relationship to producing the product including its financial amortization, usually is about 5% with probably maximum of 10% Plastic material cost could be at about 50% with as high as 80% for high volume production. The other costs include power, water, labor, overhead and taxes. With precision, short runs, costs could be equipmentwise at 20 to 30%, material 45 to 50%. Thus, as it is usually stated, do not buy equipment just because it cost less since more profit could occur with the more expensive equipment; study what is to be purchased. Of course the reverse is possibly true. So, you the buyer, have to know what you want and are ordering to a specification properly determined based on the designed product requirements.

Designing Product

In product design there has always been the desire to use less of any material, because the result is usually a lower-cost product. On the other side of the issue is the use of more

material to provide for a higher design safety factor beyond what is required. Thus, unfortunately, there are designs using more material than needed. It is inexperience in designing with plastics that causes this problem.

Many designers lack the knowledge of at least relating a material's performance to the processing variables that directly influence safety factors and the amount of a plastic to be used. With the flexibility that exists in designing with plastics, there are different approaches that may be used to reduce product volume or weight, such as applying different shapes like internal ribbing, corrugations, sandwich structures, and orienting or prestretching.

All this activity is aimed at producing products that use less in the way of materials and in turn let less material enter the solid-waste stream. Some designers have habitually listed in product design specifications that specific environmental requirements should be met. A designer sometimes has an opportunity to use a material that provides no problem in the solid-waste stream or to use a design that lets lower-cost recycled plastics be used. In fact, blends of virgin (not previously processed) plastics with recycled plastics could permit the meeting of required product performance and environmental requirements (Chapter 6, **RECYCLING**).

This approach has been used for the past century, but now there will be more use of it, as more and more recycled plastics become available. However, the designer must take into account the potential lower performances that could occur with recycled plastics. Interesting that at times recycled materials is more expensive than virgin plastics. They are used in many cases since there is a regulation (government or industry) that states the product has to contain some amount, such as 50 wt%, of recycled plastics.

The recycled plastic will also have a degree of different contaminants that would eliminate its use in certain devices or products, such as in medicine, electronics, and food packaging. However, within these market applications there are acceptable designs with three-layer coextruded, coinjected, or laminated structures having the contaminated plastic as the center layer, isolated by "clean" plastics around it and no migration occurring.

Another method of reducing the quantity of plastics that has been used in certain products is to use engineered plastics with higher performance than the lower-cost commodity plastics. When applicable, this approach permits using less material to compensate for its higher cost. With a thinner-walled construction there could also be additional cost savings, since less processing heat, pressure, and time cycle is required.

Energy

To produce and process plastics requires less energy than practically any other material (Fig. 9-8). In contrast, glass requires much more energy than any of the materials listed.

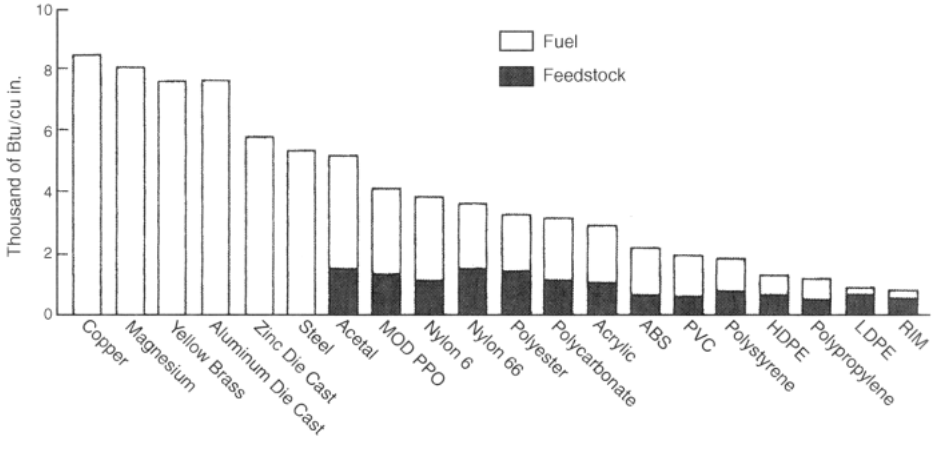

Fig. 9-8 Energy requirements for different materials.

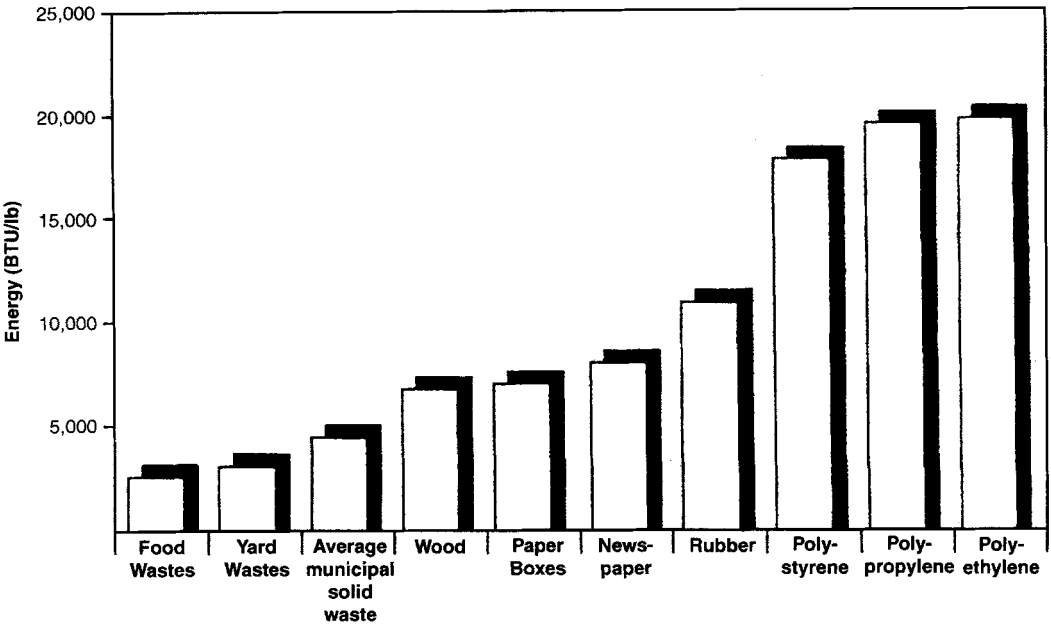

Fig. 9-9 Incineration and energy output.

Solid Waste

Only about 7 wt% of the solid waste produced are plastics. Incinerating, recycling, landfill, and other methods are used to handle the worldwide plastics (and other materials) waste problems. Incineration of plastics produces a high energy content. For example, polystyrene has nearly twice the energy content of coal, without its ensuing problems of ash, acid rain pollution, or harmful emissions. Plastics are just one of many materials that produce solid waste, and, as with other materials, there are good and bad disposal solutions. As shown in Fig. 9-9, plastic scrap and waste does provide cost savings when compared to other materials.

Competition

For over a century plastics have successfully competed with other materials in old and new applications providing cost-performance advantages, etc. In fact within the plastic industry there is extensive competition where one plastic competes with another plastic. Examples include many such as thermoplastic elastomers vs. thermoset rubbers, clarity film LLDPE vs. LDPE and PVC.

This action will continue and expand as is evident by new plastics being developed. DuPont's iron and cobalt single-site catalyst system that makes HDPE with higher melting points and performances such as adhesion, barrier performances, etc. Other examples include the expanding process techniques, and applications that are always on the next horizon. Thus to help plastics expand, there has been and will continue to exist plastic-to-plastic competition to meet all kinds of requirements, including high and safe performance in all kinds of environments. Recognize that in the future different basic raw materials will be used in addition to those already being used.

In general, companies in the plastics industry can obtain patents upon the processes they use to manufacture new materials (Chapter 4, **DESIGNING AND LEGAL MATTER**). However, since a processed patent discloses a great deal of information that may be useful to competitors even though they are not using or do not wish to use the exact process as that described in the patent. Some firms in the industry do not

patent each new process (or material) in order to maintain strict secrecy. To prepare a practical fool proof patent requires lots of money.

Plastic materials' manufacturing is primarily a large-volume, low-cost, low-unit profit margin business with great overall economies. The plastics generally compete with each other on a "money value" basis in which an economic analysis takes into account the differing densities of the various plastics in order to judge them on a cost per pound or volume basis.

Conventionally, we think of competition as being between essentially similar products on a price, quality, and service basis. In plastics, competition is much broader and often more intense.

Competition, at each stage in the plastics industry, is in their raw materials. Many monomers can be made from alternate raw materials such as polyvinyl chloride that may begin with either ethylene or acetylene. Most plastic products may be made from a variety of plastics such as pipe that may be extruded from PVC, polyethylene, ABS, and so on.

Competition is also within processes. Both plastics and finished products may be made by entirely different routes, requiring different procedures and different equipment. For example, polyvinyl chloride may be made by three different processes and thermoplastic sheets may be cast, injection molded, or extruded. Plastic competition is within the industry both locally and particularly international as well (210, 211). Plastics can compete with the products of other industries for the same application; for example, against wood, metal, and concrete in construction application, against natural fibers for textiles, and against animal glue in the adhesives field. In addition, plastics is an international business with growing industries in other countries vying with USA firms for markets both abroad and at home.

An example of the way in which process competition works in the manufacture of plastics is the story of acrylonitrile. The first process for the production of this plastic was based upon the reaction between hydrogen cyanide and acetylene, both hard to handle, poisonous, and explosive chemicals. The raw material costs were relatively low as compared to materials for other monomers, but the plant investment and manufacturing costs were too high. As a result, originally acrylonitrile monomer (1950s) sold for about 30 cents per pound and the future of the material looked dim as other plastics such as polyethylene became available at much lower prices due to their lower production costs.

During the late 1950's, chemists at the Standard Oil Company of Ohio worked

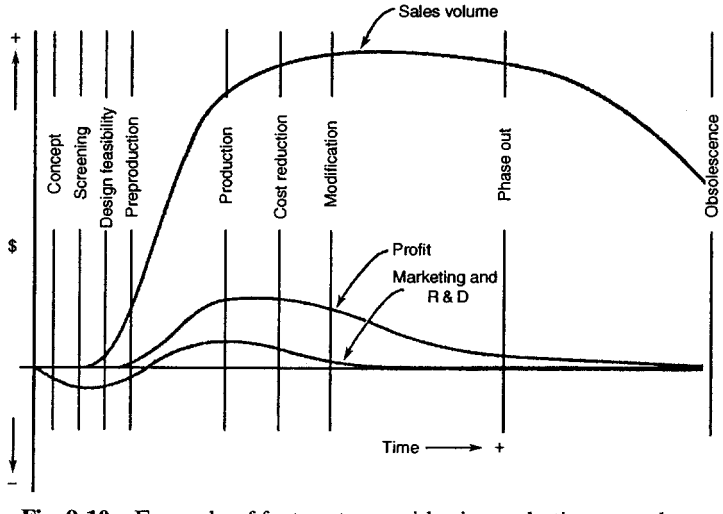

Fig. 9-10 Example of factors to consider in marketing a product.

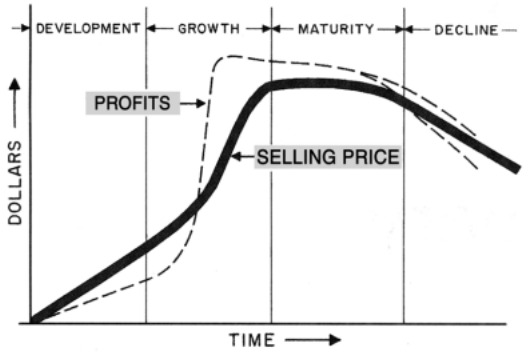

Fig. 9-11 Example for the life of a product.

Fig. 9-13 Any other operation not showing a profit.

on the development of a new process for the manufacture of acrylonitrile. In 1961, SOHIO built the first plant using their new process to produce acrylonitrile from propylene and ammonia, both materials being readily available and easy to handle. This new process used more expensive raw materials than the old one, but required only one production operation to produce the acrylonitrile monomer. This meant lower plant investment and lower manufacturing costs, and the price of the monomer went down to around 14 cents per pound.

This new lower price changed the comparative economic advantages of some of the newer plastics and led to a search for new uses of acrylonitrile and its polymers and copolymers. A new route to Dacron was developed by du Pont using this lower priced acrylonitrile and the use of acrylic fabrics grew rapidly. There was also an increase in uses of ABS and acrylonitrile production capacity.

On the other side of costs, the higher priced plastics continue to be marketable since they meet required performances for certain products. As an example polyaryletherketone (PAEK) plastic that cost $40/lb was being market in dental implants, bone replacement joints, and components for the hip, elbow, finger, knee, spine, and other body products. And so all these type of actions continue in the plastic industry worldwide.

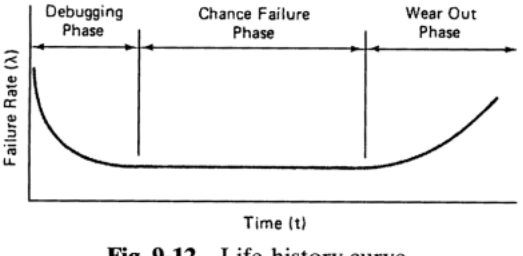

Fig. 9-12 Life-history curve.

Quotation

Document quote that states the selling price and other sales conditions of a material, product, etc. has different meanings. Did you know that by law if someone reports that verbally the vender made statements such as "buy this injection molding machine and all you have to do is push a button to make good/acceptable products" the vender is legally in trouble. Even if that person wins the case (rare), it will be very expensive to pay for the court case.

Market

Throughout this book reviews have been made on products that literally are used in many different markets. This action fits the usual statement that "this is the World of Plastics" Important with all the cost analysis is that profits have to be included. Influencing factors that involve profits are summarized in Figs. 9-10 to 9-13. The life-history curve, Fig. 9-11, shows the basic format of a typical product cycle for an infinite number of products. It is also called a "bathtub" curve.